Agricultural Water Management 208 (2018) 7–18

Contents lists available at ScienceDirect

Agricultural Water Management

journal homepage: www.elsevier.com/locate/agwat

# Irrigation water management in Iran: Implications for water use efficiency improvement

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ARTICLE INFO

*Keywords:*
Water crisis
Water efficiency
Agriculture sector
Water management
SWOT/PESTLE analysis
TOWS matrix
Bottleneck analysis
Iran

ABSTRACT

Water is the most essential resource for the production of agricultural goods and services. However, high levels of water stress and increased frequency and intensity of droughts, which are mainly driven by climate change dynamics, have reduced the stock of freshwater resources in arid and semi-arid regions, such as Iran. Despite the major reduction of freshwater resources, the efficiency of irrigation water use has remained very low in the country and performance of water management schemes is far from satisfactory. Using the strengths, weaknesses, opportunities and threats/political, economic, social, technological, legal and environmental (SWOT/PESTLE) analysis, this paper explores 40 internal and external factors that influence irrigation water management in Iran and recognizes legal, social, technological and political dynamics as the major reasons for failure of irrigation water management in the country. A combination of the threats, opportunities, weaknesses and strengths (TOWS) matrix and bottleneck analysis was used to suggest irrigation water management strategies that rehabilitate the failed schemes and enhance water security in the agriculture sector. Rethinking the role of intensified agriculture in development along with raising the awareness and attitude of decision makers towards the risk of shortsighted water resource development plans, in addition to promoting agro-based industries and developing integrated plans to improve water efficiency are the strategies that can contribute to a more effective management of irrigation water in Iran.

## 1. Introduction

Water is considered as one of the most critical resources for human beings. It is vital not only for economic development, as water resources are important to the production of agricultural and industrial goods and services, but also it is the most essential component of the natural environment (Chartzoulakis and Bertaki, 2015). Also, it has a significant influence on health and nature conservation. However, only 2.7% of global water is available as freshwater with an appropriate quality, out of which only 30% can be applied to answer human and livestock demands (Ertek and Yilmaz, 2014).

Over the past 60 years, global demand for freshwater has increased for many reasons including rapid population and economic growth (Kaur et al., 2010), urbanization and industrialization (Biswas, 2010), land use change (Sophocleous, 2004), intensive agricultural practices (Tilman et al., 2002) and environmental degradation (Vörösmarty et al., 2000). Furthermore, changes in the frequency, duration and intensity of drought events have dramatically reduced the stocks of freshwater resources in several regions (Ronco et al., 2017), especially in the arid and semi-arid areas of Iran. For instance, the 2007–2014 drought in Iran led to the complete dry up of many internationally renowned wetlands and lakes, significant reduction of river flows and depletion of groundwater resources (Keshavarz and Karami, 2016).

On the other hand, by 2050, the world's population is projected to rise to 9.8 billion people and more than half of this population will reside in urban areas (UN, 2017). As population and economic growth will continue, more food will be needed to be produced in the future.[1] It means that water demand will grow more than 40% by 2050 (UN, 2015). Therefore, water scarcity will turn out to be a great issue in the near future (Doungmanee, 2016). In parallel, climate change is expected to deteriorate the situation through significant reduction of freshwater supplies and increase of frequency, intensity and duration of drought events (IPCC, 2014). While climate change has already affected the temporal and spatial variability of surface and ground water

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[1] Approximately 50% more food compared to the data for 1998 (FAO, 2010).

https://doi.org/10.1016/j.agwat.2018.06.003
Received 2 January 2018; Received in revised form 13 May 2018; Accepted 1 June 2018
Available online 20 July 2018
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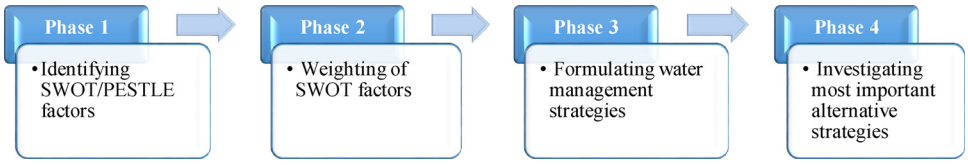


**Fig. 1.** Research framework.

availability (IPCC, 2014), it is predicted that approximately two-third of the world's population will encounter water stress conditions in 2025 (UN Water, 2010). As the available freshwater supply will become scarce, the demand for irrigation water will increase in the regions that their agricultural systems heavily depend on irrigation, such as Iran.

Irrigated agriculture is currently the major user of water resources worldwide by consuming approximately 70% of the total withdrawn water (FAO, 2013). In developing countries, like Iran, whose rural economies mainly depend on agricultural products, intensive irrigated agriculture is responsible for over 90% of freshwater consumption (Samian et al., 2015) and will continue to be the main user of renewable water resources (Rosegrant et al., 2009).

Since water scarcity is a harsh reality of the agricultural sector in arid and semi-arid regions, proper management and efficient use of agricultural water are imperative to ensure global water safety. However, water use efficiency of agriculture in Iran is very low. The average efficiency of irrigation systems in this country is about 35% (Madani, 2014), which is far lower than 70–90% irrigation system efficiency of the most developed countries (FAO, 2016).

Therefore, conservation of water resources and affordable and sustainable use of irrigation water is required to mitigate the problem of water shortage, in Iran. As the reduction of irrigation water supply and demand will pose a great risk to national food security (Kang et al., 2016) and will increase rural poverty and forced migration without diligent planning, a consistent policy of rational irrigation development is necessary. In this respect, improving the productivity of irrigated agriculture has been a priority for the government of Iran since 1960 (Forouzani and Karami, 2010). Despite increasing institutional investments in dam construction, provision of low-interest loans and implementation of various policy measures such as subsidized agricultural water and energy use, the performance of many water management schemes is far from satisfactory (Keshavarz et al., 2013; Madani, 2014; Moazedi et al., 2011). The efforts of Iran for managing irrigation water have been criticized due to the decades of disintegrated planning and management myopia (Madani, 2014). Also, the rapid investment and growth in the economy and infrastructure sectors without considering the dynamic relationships between these sectors and the water, environment and ecosystem components have been discussed (Mirchi et al., 2010). Moreover, the absence of an integrated view about the human-natural system relationship is evident in Iran, which means that the context, local realities or legitimacy are ignored during the implementation of water management practices (Hjorth and Madani, 2014). Since continuation of the current irrigation water management trends will amplify the water crisis of Iran, it is imperative to assess site-specific irrigation water management challenges and ensure sustainable management of irrigation water.

Numerous studies have applied SWOT (Strengths, Weaknesses, Opportunities and Challenges) and/or PESTLE (political, economic, social, technological, legal and environmental) analysis to different fields of water management in both developed and developing countries, e.g. Abdullaev et al., 2009; Bastiaanssen et al., 2007; Burt et al., 2006; de Souza and Costa da Silva, 2014; Gallego-Ayala and Juízo, 2011; Grigg, 2005; Jang et al., 2014; Martins et al., 2013; Michailidis et al., 2015; Molden and Oweis, 2007; Mugabi et al., 2007; Mylopoulos et al., 2008; Panigrahi and Mohanty, 2012; Srdjevic et al., 2012; Tekken and Kropp, 2015; Yavuz and Baycan, 2013. However, the factual status of irrigation water management is not well documented in Iran. Meanwhile, there is strong evidence that each country involves its unique internal, i.e. strengths and weaknesses, and external, i.e. opportunities and threats, factors that reinforce or depreciate water management. As an outcome, conducting a research related to improving irrigation water management in the Iranian context can raise awareness of water sustainability challenges and help decision makers to rehabilitate the failed schemes of irrigation water security. Therefore, this study attempts to i) identify the strengths, weaknesses, opportunities and threats of the Iranian water management practices and policies, ii) determine the most critical factors associated with sustainable management of irrigation water and iii) propose some water management strategies to ensure effective use of the limited water and alleviate irrigation water shortages, in the arid and semi-arid regions of Iran.

## 2. Research method

A four-phase decision making framework was designed to identify the critical internal and external factors that are associated with sustainable management of irrigation water resources in Iran and rank the water management strategies according to their importance (Fig. 1). The study framework is described with more details, in the subsequent sections.

### 2.1. SWOT/PESTLE analysis

SWOT/PESTLE was used to investigate the current status of irrigation water management in Iran. Generally, SWOT is a list of factors that can be used to describe present and future trends of both internal and external environments (Yavuz and Baycan, 2013). SWOT is a convenient way of conducting a situational evaluation (Wickramasinghe and Takano, 2009) and categorizing the key internal and external factors that are important for achieving sustainable water management.

In order to identify the preliminary strengths, weaknesses, opportunities and threats (SWOT) of sustainable management of Iran's irrigation water systems, the literature about irrigation water management in Iran was reviewed. In addition, three primary sources were used as a starting point including i) an expert group meeting, ii) a focus group discussion by policy makers, and iii) semi-structured interviews with the main irrigation water users i.e. farmers of the Moghan plain who hold the positions of opinion leadership (Table 1). The Moghan plain, northwest Iran, is one of the leading agricultural regions in Iran.

The farmers, who participated in this study, were selected based on

**Table 1**
General characteristics of the participants.

| Characteristics | Number | Percentage of the total sample |
|---|---|---|
| *Participants* | | |
| Farmers | 16 | 53.3 |
| Policy makers | 5 | 16.7 |
| Experts | 9 | 30.0 |
| *Gender* | | |
| Male | 28 | 93.3 |
| Female | 2 | 6.7 |
| *Education* | | |
| Ph.D. | 9 | 30.0 |
| M.Sc. | 4 | 13.3 |
| B.Sc. | 5 | 16.7 |
| Diploma | 12 | 40.0 |

their experiences in managing irrigation water systems and their familiarity with irrigation water reality in Iran. Also, the scholars that were experts in the field of managing water resources and policy makers (i.e. the local and national irrigation water managers) were selected based on their in-depth knowledge of managing irrigation water resources, professional experiences and skills, as well as individual reputation in the water sector.

The information obtained from the meeting, focus group discussion, semi-structured interviews and literature review was validated by the academic researchers and technical experts that participated in the meeting. Furthermore, the experts classified the SWOT factors across six PESTLE categories, i.e. the political, economic, social, technological, legal and environmental classes. The synergy between SWOT and PESTLE provides deep insight and accurate understanding about the current realities of complex irrigation water management processes in Iran.

### 2.2. Weighting of SWOT/PESTLE factors and assessing status of irrigation water management

SWOT analysis is a useful tool for evaluating the current status of irrigation water management. However, one of its main drawbacks is that SWOT often fails to provide information about the relative importance of the identified factors. For this reason, recently SWOT analysis has been upgraded with the Multi-Criteria Decision Making (MCDM) methods that prioritize SWOT factors by assigning some corresponding weights to them. Assigning weights to the SWOT factors forces the respondents to analyze the situation more precisely and deeper than the case of standard SWOT (Yavuz and Baycan, 2013).

Using the identified SWOT/PESTLE factors, a questionnaire was designed for the experts and policy makers in order to determine the weights of the SWOT/ PESTLE factors. The relative importance of each factor was determined using a 1–5 scale, where the score of 1 represents very low importance and 5 stands for very high importance. A total of 14 questionnaires were completed by the experts and decision makers to derive the weights of SWOT/PESTLE factors.

After determining the local weight of each SWOT factor, Eq. (1) was developed to assess the value of each PESTLE factor and explain the status of irrigation water management in Iran.

$$PESTEL\ values = f\ ((\sum w_i s_i SW\ factors)\ .\ (\sum w_i s_i OT\ factors)) \quad (1)$$

where $w_i$ is the weight of SWOT factor i, $s_i$ is the score of SWOT factor i and SW and OT are the internal (strengths and weaknesses) and external (opportunities and threats) factors, respectively. The score of each SWOT factor was determined by a panel of experts using a 1–4 scale, where a score of 1 represents failure of irrigation water management efforts to minimize the internal weaknesses or external threats, a score of 2 refers to desirable reduction or elimination of the internal weaknesses or external threats, a score of 3 indicates poor utilization of the internal strengths or external opportunities, and finally, a score of 4 relates to proper water managers efforts for reinforcing the internal strengths and achieving the external opportunities (for more information about the SWOT analysis see Sarsby, 2016).

### 2.3. Water management strategy formulation

In order to propose water management strategies to ensure sustainable management of irrigation water in Iran, a TOWS matrix (Weihrich, 1982) was employed by a panel of experts and policy makers (Fig. 2). TOWS matrix develops alternative strategies based on logical combinations of i) the internal strengths and the external opportunities and threats and ii) the internal weaknesses and the external opportunities and threats (Trainer, 2004). The matrix determines four conceptually distinct groups to provide alternative strategies including i) Strength-Opportunity (SO) strategies, when irrigation water managers and practitioners utilize and reinforce internal strengths to access the opportunities that are available in the external environment; ii) Weaknesses-Opportunity (WO) strategies, when irrigation water managers reduce the internal weaknesses that can prevent implementation of external opportunities; iii) Strength-Threats (ST) strategies, when irrigation water managers and practitioners utilize internal strengths to minimize the external factors that threaten efficient use of irrigation water; and iv) Weaknesses-Threats (WT) strategies, when irrigation water managers eliminate or minimize internal weaknesses to avoid prevalence of external threats (for more information about the TOWS analysis see Sarsby, 2016).

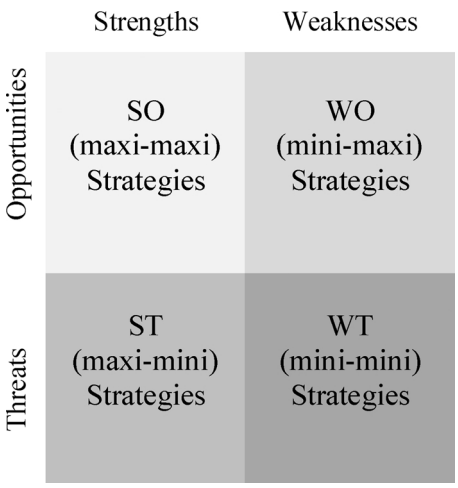


**Fig. 2.** TOWS matrix.

### 2.4. Identifying most important water management strategies

In order to create a deep understanding of the sequence and relevance of the TOWS strategies, a process map was designed. In the first step, primacy and recency of the irrigation water management strategies were discussed by a panel of experts and policy makers. In this respect, the respondents were asked to determine the prerequisites of each strategy. After that, a hierarchical network of strategies was devised to model and interpret the relationships between the water management strategies. With this regard, three types of strategies were identified by the experts and policy makers; i) initiation strategies; ii) mediation strategies; and iii) termination strategies. The yEd Graph Editor software was used to create the process map while adding a hierarchical linking structure. Accuracy of the process map was validated by a panel of experts and policy makers.

E-I index, which was formulated by Krackhardt and Stern (1988), was used to measure the ratios of the internal and external ties and standardize them into a commensurate value within the range of −1.0 to +1.0. The E-I index was calculated as:

$$\text{E−I index} = \frac{Number\ of\ external\ ties − Number\ of\ internal\ ties}{Total\ number\ of\ ties} \quad (2)$$

An E-I index of −1.0 indicates only initiation orientation of strategies whereas an E-I index of +1.0 signifies alternative termination strategies. Also, E-I measures between −1 and +1 indicate the mediation role of the strategies.

Furthermore, bottleneck analysis was carried out by the participants to identify the most important initiation, mediation and termination strategies for transformation of the current irrigation water management systems into more reliable and efficient systems. This analytical method distinguishes the most critical strategies that prevent achievement of the desired level of sustainability by an irrigation water management system. The relative importance of the strategies was determined based on four principal criteria within a 0–10 scale that was

**Table 2**
Priority scores and raking of the SWOT factors.

| SWOT | Priority score and rank | SWOT factors | Local weight | Overall weight | Overall ranking |
|---|---|---|---|---|---|
| Strengths | 0.12364 (4th) | **S1**: Planning for development of resilient water management system | 0.19841 | 0.02453 | 29 |
| | | **S2**: Contribution of agriculture sector to 23% of employment | 0.19395 | 0.02398 | 30 |
| | | **S3**: Considering food security as a national priority | 0.21081 | 0.02607 | 20 |
| | | **S4**: Diversification of agricultural products and incomes | 0.22569 | 0.02791 | 6 |
| | | **S5**: Contribution of agriculture sector to 13% of GDP | 0.17113 | 0.02116 | 33 |
| Weakness | 0.40822 (1st) | **W1**: Weak inter-institutional communications and inadequate dissemination of information to farmers | 0.06551 | 0.02674 | 12 |
| | | **W2**: Low effectiveness of extension services for improving information about irrigation water management | 0.06881 | 0.02809 | 3 |
| | | **W3**: Weak regulation and monitoring of water uses | 0.06415 | 0.02619 | 18 |
| | | **W4**: Presumption of regional homogeneity and overlooking relative advantages of each region for development | 0.06415 | 0.02619 | 19 |
| | | **W5**: Insufficient funding and regulation for implementation of land consolidation projects | 0.06385 | 0.02607 | 21 |
| | | **W6**: Inadequate implementation of the current regulatory framework | 0.06505 | 0.02656 | 14 |
| | | **W7**: Leave no incentives for farmers to increase efficiency of irrigation water use | 0.06881 | 0.02809 | 4 |
| | | **W8**: Weak empowerment of farmers for sustainable use of irrigation water | 0.06761 | 0.02760 | 8 |
| | | **W9**: Inadequate water tariffs | 0.06686 | 0.02729 | 10 |
| | | **W10**: Lack of strong water consumption adjustment programs | 0.06505 | 0.02656 | 15 |
| | | **W11**: Mismatch of crop pattern with regional water availability conditions | 0.06641 | 0.02711 | 11 |
| | | **W12**: Unavailability of reliable data and information | 0.06505 | 0.02656 | 16 |
| | | **W13**: Failure to meter water use | 0.06881 | 0.02809 | 5 |
| | | **W14**: Failure to establish regional cooperative water management institutions | 0.07016 | 0.02864 | 1 |
| | | **W15**: Poor social capital | 0.06971 | 0.02846 | 2 |
| Opportunities | 0.20570 (3rd) | **O1**: Increasing awareness about the crucial role of investment in developing resilient irrigation water management systems | 0.08676 | 0.01785 | 40 |
| | | **O2**: Restriction of water use in plains that are under critical conditions | 0.09839 | 0.02024 | 35 |
| | | **O3**: Improvement of regional and global water markets | 0.10584 | 0.02177 | 32 |
| | | **O4**: Decentralization of water management | 0.10286 | 0.02116 | 34 |
| | | **O5**: Increasing use of outgoing surface flows | 0.09243 | 0.01901 | 38 |
| | | **O6**: Learning from advanced and successful water management projects | 0.09481 | 0.01950 | 37 |
| | | **O7**: Adequate technical knowledge about extracting, transferring and distributing irrigation water | 0.09243 | 0.01901 | 39 |
| | | **O8**: Funding opportunities from national investors | 0.09541 | 0.01963 | 36 |
| | | **O9**: Improving rural tourism | 0.10942 | 0.02251 | 31 |
| | | **O10**: Promotion of agro-based industries | 0.12165 | 0.02502 | 28 |
| Threats | 0.26243 (2nd) | **T1**: Declining surface and ground water resources, and land subsidence | 0.10189 | 0.02674 | 13 |
| | | **T2**: Increasing water use tension and competition between agricultural and non-agricultural sectors | 0.10119 | 0.02656 | 17 |
| | | **T3**: Agro-based rural economy that impose extensive pressure on water resources | 0.09745 | 0.02557 | 26 |
| | | **T4**: Limited control over groundwater abstraction | 0.10633 | 0.02791 | 7 |
| | | **T5**: Increasing competition over transboundary water systems | 0.09769 | 0.02564 | 23 |
| | | **T6**: Deteriorating water quality | 0.09769 | 0.02564 | 24 |
| | | **T7**: Populist actions of decision makers and paying less attention to experts' recommendations | 0.10516 | 0.02760 | 9 |
| | | **T8**: Absence of an integrated view about sustainable agriculture and planning shortsighted development projects | 0.09558 | 0.02508 | 27 |
| | | **T9**: Aggressive use of irrigation water | 0.09769 | 0.02564 | 25 |
| | | **T10**: Instability of water governance structure and uncoordinated development of the agriculture sector | 0.09932 | 0.02607 | 22 |

consistently considered by the panel of experts. The principal criteria included the ability of each strategy to i) stimulate healthy economic productivity and profitability (EP); ii) increase physical productivity (PP); iii) increase employment opportunities (EO); and iv) provide sustainable water resources management (SWM). The weights of initiation, mediation and termination strategies were calculated using the following formula:

$$V_j = (EI_j)\left(\frac{EP_j + PP_j + EO_j + SWM_j}{40}\right) \quad (3)$$

where $V_j$ is the relative importance of strategy j and $EI_j$ is the number of the internal and external ties that are related to the $j^{th}$ strategy.

## 3. Results and discussion

### 3.1. Identifying SWOTs of irrigation water management in Iran

The results of the SWOT analysis allowed identification of 40 critical factors that influence irrigation water management in Iran (Table 2). These factors form the internal and external environment of irrigation water management and can be divided into the four groups of strengths (5 factors), weaknesses (15 factors), opportunities (10 factors) and threats (10 factors). As Table 2 indicates, the panel of experts and policy makers assigned the highest priorities to the weaknesses (40.82%) and threats (26.24%). Meanwhile, the opportunities (20.57%) and strengths (12.37%) were ranked the third and fourth with respect to the significant of their effects on determining irrigation water management in Iran (Table 2). This implies that the weaknesses of the irrigation water management system existing in Iran dominate its strengths and the threats determine the water management system of Iran rather than the opportunities.

According to the weaknesses group of factors, 'failure to establish cooperative water management institutions' (W14, 0.0286), 'poor social capital' (W15, 0.0285) and 'low effectiveness of extension services' (W2, 0.0281) represent the highest priorities (Table 2). This finding reflects the importance of considering the social and institutional

determinants of irrigation water management. The other eight key factors that are outlined in Table 2 include 'lack of incentives' (W7, 0.0281), 'failure to meter water use' (W13, 0.0281), 'weak empowerment of farmers' (W8, 0.0276), 'inadequate water tariffs' (W9, 0.0273), 'mismatch of crop pattern with water availability conditions' (W11, 0.0271), 'weak inter-institutional communications' (W1, 0.0267), 'inadequate implementation of the regulatory framework' (W6, 0.0266) and 'lack of strong water use adjustment programs' (W10, 0.0266).

In the case of the threats group of factors, the experts and policy makers perceived that 'limited control over groundwater abstraction' (T4, 0.0279) should be considered as one of the key factors of inefficient irrigation water management in Iran (Table 2), followed by 'populist actions of decision makers' (T7, 0.0276), 'declining water resources and land subsidence' (T1, 0.0267), 'increasing water use tension and competition' (T2, 0.0266) and 'instability of water governance structure' (T10, 0.0261).

Among the ten factors identified as the opportunities for improving irrigation water management, 'promotion of agro-based industries' (O10, 0.0250) represents the highest priority (Table 2), followed by 'improving rural tourism' (O9, 0.0225), 'improvement of water markets' (O3, 0.0218) and 'decentralization of water management' (O4, 0.0212). Finally, 'diversification of agricultural products and incomes' (S4, 0.0279) is the strength factor with the highest priority, followed by 'considering food security as a national priority' (S3, 0.0261) and 'planning for development of resilient water management system' (S1, 0.0245).

### 3.2. Current status of irrigation water management in Iran: PESTLE analysis

PESTLE analysis was used to investigate the current status of irrigation water management in Iran (Table 3). In this respect, the SWOT factors were divided into the six groups of political (6 internal and 9 external factors), economic (7 internal and 6 external factors), social (11 internal and 3 external factors), technological (4 internal and 1 external factors), legal (2 internal and 1 external factors) and environmental (1 internal and 7 external factors), which are explained in the following subsections.

#### 3.2.1. Political factors

As it is displayed in Fig. 3, the experts and policy makers acknowledged the fact that political factors are the major drivers of the current inefficient irrigation water management in Iran. The experts and policy makers perceived some major political reasons for the irrigation water crisis of Iran, i.e. dried up surface water resources and declined groundwater tables. They believed that the national desire for self-sufficiency in wheat production, planning to achieve food security through rapid investment in constructing dams and centralization of water management have imposed extra pressure on water resources. Furthermore, instability of water governance structure, inadequate implementation of the regulatory framework, lack of adequate monitoring data and poor irrigation water allocation and distribution systems have intensified the irrigation water crisis in Iran. It is worth noting that 277 out of the 609 plains of Iran are under critical conditions (Forootan et al., 2014) and extensive over-drafting of groundwater from the confined and semi-confined aquifers has led to a major land subsidence in many plains (Dehghani et al., 2013).

Also, the literature review showed that over-irrigation happened during the 30-years period that Iran was experiencing its most extensive and severe drought. It is while metering irrigation water use to control water balance and productivity remains overlooked and farmers were not found to be eager to improve their traditional water management strategies. This is mainly because decision makers are more interested in populist development agendas that produce immediate economic impacts (Madani, 2014). As an outcome of over-irrigation, overexploitation of aquifers and inadequate access to drinking water, irrigation water has been diverted from the agricultural sector to drinking supplies (Mousavi, 2005), especially in the central and southern parts of the country. This compulsory turn is normally the product of nonexistent water resource management plans and managerial myopia. Furthermore, the absence of an integrated water management view and implementing short-sighted water policies, such as adjustment of water management boundaries from watershed to political (provincial) boundaries, have exacerbated competitions between the provinces to increase their gains from the shared watersheds (Zarezadeh et al., 2013). Moreover, Iran's efforts to increase its use of the outgoing surface flows and transboundary aquifers, such as the Sarakhs, Astara and Nakhichevan aquifers, can increase international conflicts with the neighboring countries (Madani, 2014).

#### 3.2.2. Economic factors

As Fig. 3 exhibits, the participants perceived that the current status of irrigation water management is at a moderate level, based on both internal and external economic factors. Currently, agriculture, as the dominant sector in the Iranian rural economy, accounts for almost 23% of employment, 13% of GDP, 20% of non-oil exports and 85% of raw materials used in food processing industries (Islamic Republic News Agency, IRNA, 2017). In order to achieve food security and increase non-oil revenues, Iran's government has tried to invest sufficiently in the development of agricultural systems. However, the economic efficiency of this sector has significantly reduced due to the negative impacts of droughts and climate change. While diversification of agricultural products and incomes can reduce the risks of water scarcity, most Iranian farm families have no job rather than farming. Therefore, they deepen their wells continuously or dig new wells to withdraw groundwater from depleting aquifers. Aggressive use of water resources without adequate vision on irrigation water management can lead to unsustainable agricultural production in arid and semi-arid regions of Iran.

To manage irrigation water demands in a sustainable way, water prices and tariffs require to be determined based on the scarcity of water resources. However, irrigation water prices and tariffs are not high enough to be prohibitive, in Iran. Also, water markets are increasingly proposed as an efficient approach to reallocate irrigation water under water scarcity and promote economic development in rural communities (Bjornlund, 2003). However, Iran has much to do to develop water market mechanisms and there is an inconsistency between irrigation water supply and demand. The inconsistency leads to the use of the brackish and saline drainage water in irrigation. Furthermore, while most policies have focused on matching crop patterns with regional water delivery capacities, crop pattern is not suitable and follows traditional crop choices, in some arid and semi-arid regions. Lack of knowledge and information about advanced crop management systems that require less irrigation water implies absence or ineffectiveness of extension programs in most parts of the country.

#### 3.2.3. Social factors

As discussed by the participants, low level of social factors is a key weakness of irrigation water management in Iran (Fig. 3). While only 15% of the Iran's area is arable, the agriculture sector consumes over 90% of freshwater in the country (Samian et al., 2015). The country is now suffering from inadequate vision on irrigation water management due to limited control over groundwater abstraction, weak monitoring of water usage and lack of strong water use adjustment plans. Moreover, lack of effective coordination among authorities of the water sector with authorities of other institutes and ministries has intensified water crisis in arid and semi-arid regions of Iran. While this country is experiencing a serious water crisis, some authorities outside the water sector are trying to protect farmers against agricultural water allocation policies that lessen irrigation water shares to conserve the environment (Madani, 2014). Inter-institutional coordination can be improved by partial decentralization of water resource management. However, the

**Table 3**
Weights and scores of PESTLE factors.

| PESTLE | Internal factors | | | | External factors | | | |
|---|---|---|---|---|---|---|---|---|
| | SWOT factors | Weight | Score | Overall value | SWOT factors | Weight | Score | Overall value |
| Political | S1 | 0.15528 | 4 | 0.62112 | O2 | 0.09280 | 4 | 0.37120 |
| | S3 | 0.16498 | 3 | 0.49495 | O4 | 0.09702 | 3 | 0.29106 |
| | W4 | 0.16576 | 1 | 0.16576 | O5 | 0.08718 | 3 | 0.26153 |
| | W6 | 0.16809 | 1 | 0.16809 | T1 | 0.12261 | 1 | 0.12261 |
| | W12 | 0.16809 | 1 | 0.16809 | T2 | 0.12177 | 1 | 0.12177 |
| | W13 | 0.17780 | 1 | 0.17780 | T5 | 0.11755 | 1 | 0.11755 |
| | | | | | T7 | 0.12655 | 1 | 0.12655 |
| | | | | | T8 | 0.11502 | 1 | 0.11502 |
| | | | | | T10 | 0.11952 | 1 | 0.11952 |
| Economic | S2 | 0.13020 | 4 | 0.52081 | O1 | 0.13079 | 3 | 0.39236 |
| | S4 | 0.15152 | 3 | 0.45456 | O3 | 0.15955 | 3 | 0.47865 |
| | S5 | 0.11489 | 3 | 0.34466 | O8 | 0.14382 | 3 | 0.43146 |
| | W2 | 0.15251 | 1 | 0.15251 | O10 | 0.18337 | 3 | 0.55011 |
| | W9 | 0.14819 | 1 | 0.14819 | T2 | 0.19461 | 1 | 0.19461 |
| | W11 | 0.14719 | 2 | 0.29437 | T9 | 0.18787 | 1 | 0.18787 |
| | W14 | 0.15551 | 1 | 0.15551 | | | | |
| Social | W1 | 0.08956 | 1 | 0.08956 | T3 | 0.32326 | 1 | 0.32326 |
| | W3 | 0.08772 | 1 | 0.08772 | T4 | 0.35271 | 1 | 0.35271 |
| | W5 | 0.08730 | 2 | 0.17461 | T9 | 0.32403 | 1 | 0.32403 |
| | W6 | 0.08895 | 1 | 0.08895 | | | | |
| | W7 | 0.09408 | 1 | 0.09408 | | | | |
| | W8 | 0.09244 | 1 | 0.09244 | | | | |
| | W10 | 0.08895 | 1 | 0.08895 | | | | |
| | W11 | 0.09080 | 2 | 0.18159 | | | | |
| | W12 | 0.08895 | 1 | 0.08895 | | | | |
| | W14 | 0.09593 | 1 | 0.09593 | | | | |
| | W15 | 0.09532 | 1 | 0.09532 | | | | |
| Technological | W1 | 0.24731 | 1 | 0.24731 | T9 | 1.0000 | 1 | 1.0000 |
| | W3 | 0.24220 | 1 | 0.24220 | | | | |
| | W11 | 0.25071 | 2 | 0.50142 | | | | |
| | W13 | 0.25978 | 1 | 0.25978 | | | | |
| Legal | W5 | 0.49534 | 2 | 0.99068 | T8 | 1.0000 | 1 | 1.0000 |
| | W6 | 0.50466 | 1 | 0.50466 | | | | |
| Environmental | S4 | 1.0000 | 3 | 3.0000 | O6 | 0.11848 | 3 | 0.35544 |
| | | | | | O7 | 0.11550 | 3 | 0.34650 |
| | | | | | O9 | 0.13674 | 3 | 0.41021 |
| | | | | | T1 | 0.16244 | 1 | 0.16244 |
| | | | | | T3 | 0.15537 | 1 | 0.15537 |
| | | | | | T5 | 0.15574 | 1 | 0.15574 |
| | | | | | T6 | 0.15574 | 1 | 0.15574 |

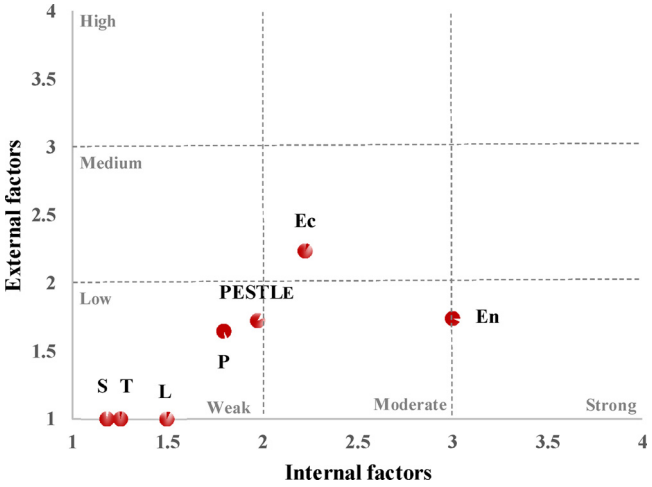


**Fig. 3.** Current status of irrigation water management in Iran. 'P, 'Ec', 'S', 'T', 'L' and 'En' stand for 'political', 'economic', 'social', 'technological', 'legal' and 'environmental' factors, respectively.

government has failed to establish regional cooperative institutes of water management and clarify the management roles of these institutes in irrigation projects.

Also, a comprehensive plan for prioritization of social capitals and empowerment of farmers (W8) has been never designed in Iran. Moreover, the government has never considered adequate economic and non-economic incentives for efficient water use. To support agricultural producers, decision makers have significantly subsidized agricultural water and energy use. Substantial subsidization of water and energy has not provided any motivation for increasing water efficiency in the agriculture sector.

### 3.2.4. Technological factors

As perceived by the experts and policy makers and demonstrated in Fig. 3, low adoption of agricultural technologies is one of the weaknesses of agricultural water resource management, in Iran. The respondents believed that aggressive use of irrigation water by using groundwater pumping technologies has significantly increased in most parts of the country. Moreover, government's failure to meter water use through installation of smart groundwater monitoring devices has exacerbated water crisis in the agriculture sector. While adoption of specific water saving technologies can increase water efficiency in the agriculture sector, the low economic capacity of most farm families (i.e. low income and insurance and poor access to credit or loans) has prevented them from application of these technologies (Keshavarz, 2016). As a result, only 5% of the total irrigated land is under pressured irrigation (FAO, 2008). Beside adoption of pressured irrigation, different water conservation practices, such as land leveling and improving water transfer system, can help farmers to distribute water properly

throughout their cropping fields and increase water efficiency. However, participants perceived that adoption of these measures is directly tied to the financial support provided by the government.

#### 3.2.5. Legal factors

As Fig. 3 exhibits, one of the main factors that threatens the sustainability of irrigation water management is weakness in legal factors. Some laws, regulations and programs have been developed to address water problems and improve water resource management. While they cover most important aspects of water management, the current implementation of these laws and regulations is inadequate. It is perceived that water management is heavily relies on a 'crisis management paradigm'. It means that policy makers continue the separation of development from environmental issues in the search for short-term economic benefits, hoping that no serious problem would interrupt their agenda (Madani, 2014). If any problem arises from their short-sighted development plans, i.e. increasing water crisis, further effort would be devoted to solving the problem's symptoms to alleviate the situation up to a semi-normal level.

#### 3.2.6. Environmental factors

According to the external factors, the current performance of the irrigation water management system is environmentally unsustainable (Fig. 3). Iran has used most groundwater reservoirs and is currently among the top groundwater users in the world (Döll et al., 2014). Moreover, increased levels of nutrients and salinity have deteriorated water quality of both surface and groundwater resources of the country (Table 2). Poor quality of irrigation water (i.e. the presence of large quantities of soluble salts), coupled with limited precipitation and high evaporation, have significantly reduced the soil quality and affected the sustainability of crop production (Jalali and Merrikhpour, 2008). Since the rural economy of Iran depends on agricultural and agro-based industries, soil and water degradations have created substantial challenges for farm families and have seriously reduced their incomes. Failure to diversify income resources has also increased a tendency towards abandoning farming and out-migration, in some water scarce regions.

In order to mitigate long-term negative consequences of farming practices on natural water resources, learning from successful water management projects and enhancing technical knowledge and information about advanced methods of extracting, transferring and distributing irrigation water are imperative (Keshavarz, 2016). However, farmers have failed to learn from advanced water management experiences and efficiency of irrigation water is still low.

### 3.3. Strategies for securing sustainable management of irrigation water in Iran

#### 3.3.1. Looking for solution strategies

PESTLE analysis revealed that irrigation water management is not efficient, in Iran (Fig. 3) and the present strategies are inadequate to solve irrigation water problems. As pressure on irrigation water resources is increasing, there is a growing need for new strategies to solve the present problems of the water and agriculture sectors. In order to propose new solutions, TOWS matrix was used by the panel of experts and policy makers. It permitted determination of 30 strategies for mitigation of irrigation water problems (Table 4). These strategies were classified as Strength-Opportunity (SO: 10 strategies), Weaknesses-Opportunity (WO: 12 strategies), Strength-Threats (ST: 5 strategies) and Weaknesses-Threats (WT: 3 strategies) groups (Table 4).

Furthermore, causal relationships among irrigation water management strategies were determined by the panel of experts (Fig. 4). According to Fig. 4, it is apparent that improving irrigation water management in Iran requires implementation of a complex web of strategies.

After setting up the causal diagram, TOWS strategies were categorized as initiation (5), mediation (20) and termination (5) strategies using E-I index (Table 5). Finally, the prominent strategies were evaluated based on Eq. (3) (Table 5). These strategies are briefly described in the following sections.

#### 3.3.2. Prominent strategies for improving irrigation water management in Iran

*3.3.2.1. Initiation strategies.* As indicated in Fig. 5, 'rethinking the role of intensified agriculture on national development of Iran' (WO1) is the first and most important strategy for ensuring sustainable management of irrigation water in Iran.

Since the Islamic Revolution of Iran, the agriculture sector has received many supports from the government in order to ensure food supply, increase non-oil production revenues and alleviate poverty in rural areas. However, contribution of agriculture to overall growth has reduced from over 33% to 13% (Islamic Republic News Agency, IRNA, 2017). While the agriculture sector is under extra pressure to be an effective engine for economic growth of rural Iran, continuous agricultural growth will be difficult due to groundwater depletion, soil degradation and drought. Moreover, climate change is projected to increase pressure on water resources and reduce agricultural production (IPCC, 2014). In order to ensure sustainable management of water resources, rethinking the role of intensive agriculture on national development is imperative. Although the climate change impacts on the arid and semi-arid regions cannot be prevented, there is still a great room for managing the tradeoffs of agricultural intensification by considering more sustainable production systems, e.g. multifunctional agriculture (Moon, 2015) and reinforcing non-farm economy, to ensure food security and poverty eradication (Keshavarz et al., 2017).

Also, as indicated in Fig. 5, to protect water resources from destructive actions of farmers, priority should be given to enhancing social capital (WO11). Most governmental support mechanisms fail to equip farmers with appropriate knowledge and information or empower them to involve in water management projects. This is while adaptive co-management of water resources, i.e. cooperation of various stakeholders and institutions, is required to cope with the increasing water crisis in Iran. Facilitating participation of farmers in water management projects and providing opportunities for them to communicate with other stakeholders and higher authorities can increase the productivity of agriculture. Empowerment of farmers can be done by providing training about water resource management issues and provisioning incentives for formation of local cooperative water management institutions or rehabilitation of traditional water user associations, i.e. the Ab-baran.

Based on the experts' viewpoints, failure in modeling climate system, deficiency of accurate weather forecasts or lack of effective early warning systems can obstruct sustainable management of water resources. Therefore, improving climate modeling and facilitating access to reliable data and information is imperative (Fig. 5; WO4). Improved access to climatic data and information can contribute to sustainable water management through several pathways. First, it persuades making better decisions about farming systems and water resources, i.e. schedule irrigation, to minimize the potential damages and stabilize income. Secondly, availability of climate predictions provides opportunities for research centers to introduce new and more adaptive crop types for various regions and allows diversification of high-value products. Third, it can contribute to developing the methods that promote crop and livestock production, in the case of climatic conditions that are beyond the range of recent experiences.

*3.3.2.2. Mediation strategies.* According to Fig. 5, in order to ensure sustainable use of irrigation water clarification of current status and future challenges of water and agriculture sectors is needed (ST4). Iran is one of the world's water-scarce regions and its per capita freshwater availability is about 2000 $m^3$ per year. However, it is projected that it will reduce to 1500 $m^3$ per capita per year by 2030 (Yang et al., 2003).

**Table 4**
TOWS matrix for mitigation of irrigation water management problems.

| SO (maxi-maxi) strategies | WO (mini-maxi) strategies |
|---|---|
| **SO1**: Prohibiting further water abstraction from plains that are under critical conditions | **WO1**: Rethinking the role of intensified agriculture on national development of Iran |
| **SO2**: Implementation of an efficient water market | **WO2**: Ensuring reasonable food production |
| **SO3**: Developing low water consuming industries | **WO3**: Analysis of knowledge and information about water-saving agricultural practices |
| **SO4**: Sustainable development of rural tourism | **WO4**: Improving climate predictions and access to reliable water resources data |
| **SO5**: Promotion of agro-based industries | **WO5**: Offering specific official training opportunities about efficient use of water resources |
| **SO6**: Diversification of agricultural products and incomes | **WO6**: Outreach of extension services and increasing effectiveness of extension programs |
| **SO7**: Implementing water projects with the support of international agencies | **WO7**: Appointment of water authorities with high levels of technical and professional competencies |
| **SO8**: Increasing adoption of water-efficient technologies | **WO8**: Human resource development planning in the water supply sector |
| **SO9**: Reaching an agreement over sharing of the transboundary aquifers | **WO9**: Technical and vocational training of experts and change agents |
| **SO10**: Formation of regional cooperative agricultural water management institutions | **WO10**: Marketing of agricultural products |
| | **WO11**: Enriching social capital |
| | **WO12**: Using public media to share information and educate public about sustainable water management |

| ST (maxi-mini) strategies | WT (mini-mini) strategies |
|---|---|
| **ST1**: Promoting participatory water management and preventing populist development actions | **WT1**: Metering water use in agriculture and industries |
| **ST2**: Development of integrated plans to improve water efficiency | **WT2**: Reducing cultivation of high water requirement crops and developing entrepreneurship in the rural environment |
| **ST3**: Raising managers' awareness and attitude toward the risk of water resource development plans | **WT3**: Modification of inappropriate crop patterns with respect to regional resource availability conditions |
| **ST4**: Clarification of the current status and future challenges of water and agriculture sectors | |
| **ST5**: Modification of water management boundaries from provincial to watershed boundaries and conflict resolution among stakeholders in the watershed boundaries | |

Therefore, climate change has important implications for the agriculture sector, as the major water consumer. Climate change is expected to limit crop production, increase irrigation water requirement, deteriorate farm families' income and reduce agricultural employment (Karimi et al., 2017). In order to enhance resilience against climate change and maintain water security, it is imperative for governors to appreciate the complexity of human-natural systems. So that, raising their awareness and attitude toward risks of water resource development plans is required (Fig. 5; ST3). Without risk awareness, it will be very difficult to address real water problems and promote a behavior change towards non-populist development actions.

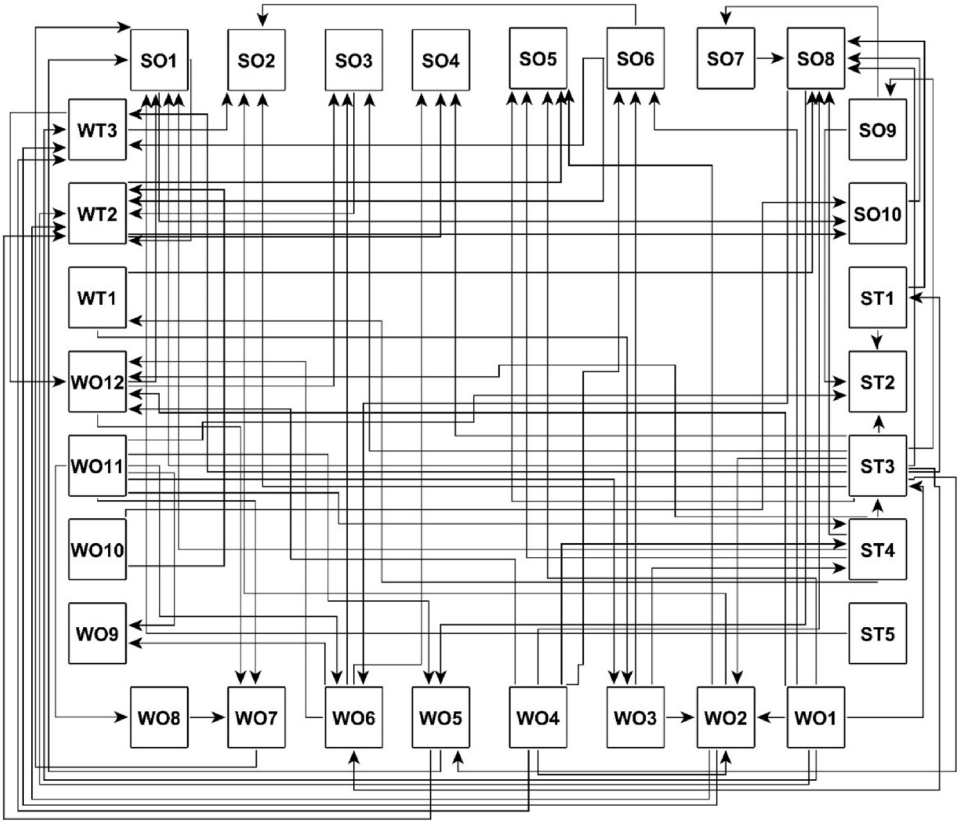


**Fig. 4.** Mapping relevancy of the TOWS strategies.

**Table 5**
Relative importance of strategies.[e]

| Type | Strategy | E-I index | EP[a] score | PP[b] score | EO[c] score | SWM[d] score | EI score | Importance score |
|---|---|---|---|---|---|---|---|---|
| Initiation | WO1 | −1.00 | 10 | 10 | 10 | 10 | 7 | 7.00 |
| | WO11 | −1.00 | 6 | 8 | 8 | 10 | 8 | 6.40 |
| | WO4 | −1.00 | 10 | 8 | 8 | 10 | 6 | 5.40 |
| | WO10 | −1.00 | 8 | 10 | 10 | 10 | 2 | 1.90 |
| | ST5 | −1.00 | 5 | 8 | 10 | 10 | 1 | 0.83 |
| Mediation | ST3 | −0.71 | 10 | 10 | 10 | 10 | 14 | 14.0 |
| | ST4 | −0.33 | 10 | 10 | 10 | 10 | 9 | 9.00 |
| | WT2 | 0.40 | 10 | 8 | 10 | 8 | 10 | 9.00 |
| | SO8 | 0.56 | 10 | 8 | 5 | 10 | 9 | 7.47 |
| | WO6 | −0.14 | 10 | 10 | 10 | 10 | 7 | 7.00 |
| | WO2 | 0.00 | 10 | 8 | 8 | 10 | 8 | 6.80 |
| | WO12 | 0.25 | 8 | 8 | 8 | 10 | 8 | 6.80 |
| | WT3 | 0.43 | 10 | 10 | 8 | 10 | 7 | 6.65 |
| | SO6 | 0.00 | 10 | 10 | 8 | 10 | 6 | 5.70 |
| | WO3 | −0.20 | 8 | 10 | 10 | 10 | 5 | 4.75 |
| | SO10 | 0.50 | 8 | 10 | 10 | 10 | 4 | 3.80 |
| | WO5 | 0.20 | 8 | 6 | 6 | 8 | 5 | 3.75 |
| | ST1 | −0.33 | 8 | 10 | 10 | 10 | 3 | 2.85 |
| | WT1 | −0.33 | 10 | 10 | 8 | 10 | 3 | 2.85 |
| | WO7 | 0.50 | 4 | 6 | 8 | 10 | 4 | 2.80 |
| | SO3 | 0.50 | 5 | 8 | 10 | 5 | 4 | 2.80 |
| | SO1 | −0.50 | 0 | 0 | 0 | 10 | 8 | 2.00 |
| | SO9 | −0.33 | 2 | 8 | 8 | 8 | 3 | 1.95 |
| | WO8 | 0.00 | 4 | 6 | 8 | 10 | 2 | 1.40 |
| | SO7 | 0.00 | 5 | 5 | 5 | 5 | 2 | 1.00 |
| Termination | SO5 | 1.00 | 6 | 8 | 10 | 8 | 5 | 4.00 |
| | ST2 | 1.00 | 10 | 10 | 10 | 10 | 4 | 4.00 |
| | SO2 | 1.00 | 6 | 8 | 4 | 8 | 4 | 2.60 |
| | SO4 | 1.00 | 2 | 5 | 10 | 10 | 3 | 2.04 |
| | WO9 | 1.00 | 8 | 8 | 6 | 10 | 2 | 1.60 |

[a] Economic productivity and profitability.
[b] Physical productivity.
[c] Employment opportunities.
[d] Sustainable water resources management.
[e] See Section 2.4 for description of the principal criteria and measurement of the importance score.

As it is shown in Fig. 5, the issue of irrigation water scarcity can be partially solved through adopting water-efficient technologies (SO8). As discussed by Wang et al. (2002), an integrated system should be considered that supports the three components of rational utilization of agricultural water resources, water-saving irrigation and agronomic water-saving techniques (Wang et al., 2002). Though there are various traditional water-saving technologies, e.g. border irrigation, furrow irrigation and land leveling, household-based water-saving technologies, e.g. ground pipes, plastic film cover, stubble retention and growing drought-resistant varieties, and community-based technologies, e.g. pressured irrigation and anti-seepage channel, overall adoption level is low in Iran. Adoption of water-efficient technologies is determined by a complex set of factors, among which scarcity of water resources and policy interventions are the main determinants (Keshavarz and Karami, 2014). Therefore, enhancing adoption of water-saving technologies, extension of water-saving technologies (Fig. 5; SO8) and subsidizing community-based water-efficient technologies are effective policy tools. Agricultural extension services can play great roles in promoting the ability of farmers to manage water resources. In this way, farmers that have more contacts with extension agents would show a higher likelihood to implement water-efficient technologies.

Nowadays, severe water scarcity, mismanagement of available water resources and inappropriate crop patterns have led to increased food imports (FAOSTAT, 2013). Increasing food imports may pose serious economic and political challenges for Iran. Participants perceived that filling the food associated gaps and ensuring reasonable food production (Fig. 5; WO2), requires some adjustments with respect to the food security priorities and regional water availability conditions. Also, there is a crucial need of revisiting inappropriate policies that encourage groundwater mining, such as cultivation of high water requirement crops (Fig. 5; WT3), in arid and semi-arid regions of Iran. Promoting low water requirement crops and providing long-term incentives for water resource management through fostering entrepreneurship in the rural environment of arid and semi-arid regions are offered by the respondents. Also, it is necessary to make public media more responsive to the significance of water resource problems of Iran (Fig. 5; WO12). Like many other developing countries, Iranian people do not properly value the ecosystem services and cannot fully understand the trade-offs between rapid shortsighted development plans and their long-term environmental consequences (Madani, 2014). Public media is a great platform to share information and educate people about values of ecosystem services and sustainable management of water resources.

*3.3.2.3. Termination strategies*. Based on Fig. 5, promotion of agro-based industries (SO5) and development of integrated plans to improve water efficiency (ST2) are two key termination strategies for ensuring sustainable management of irrigation water. Generally, agro-based industries are small or medium sized enterprises that add value to agricultural products through processing them into edible or non-edible products. Agro-based industries can offer employment opportunities, enhance income and profitability within local communities (Epstein and Jezeph, 2001) and reduce extra pressures on water resources by comprising vertical integration towards the market. However, agro-based industries have remained rudimentary and have received inadequate support from the government.

Furthermore, the ability of farmers to contribute effectively to the growth process depends on addressing the complexity and uncertainties of the irrigation water system and improving irrigation water efficiency. To reach these goals, exploitation and use of non-conventional

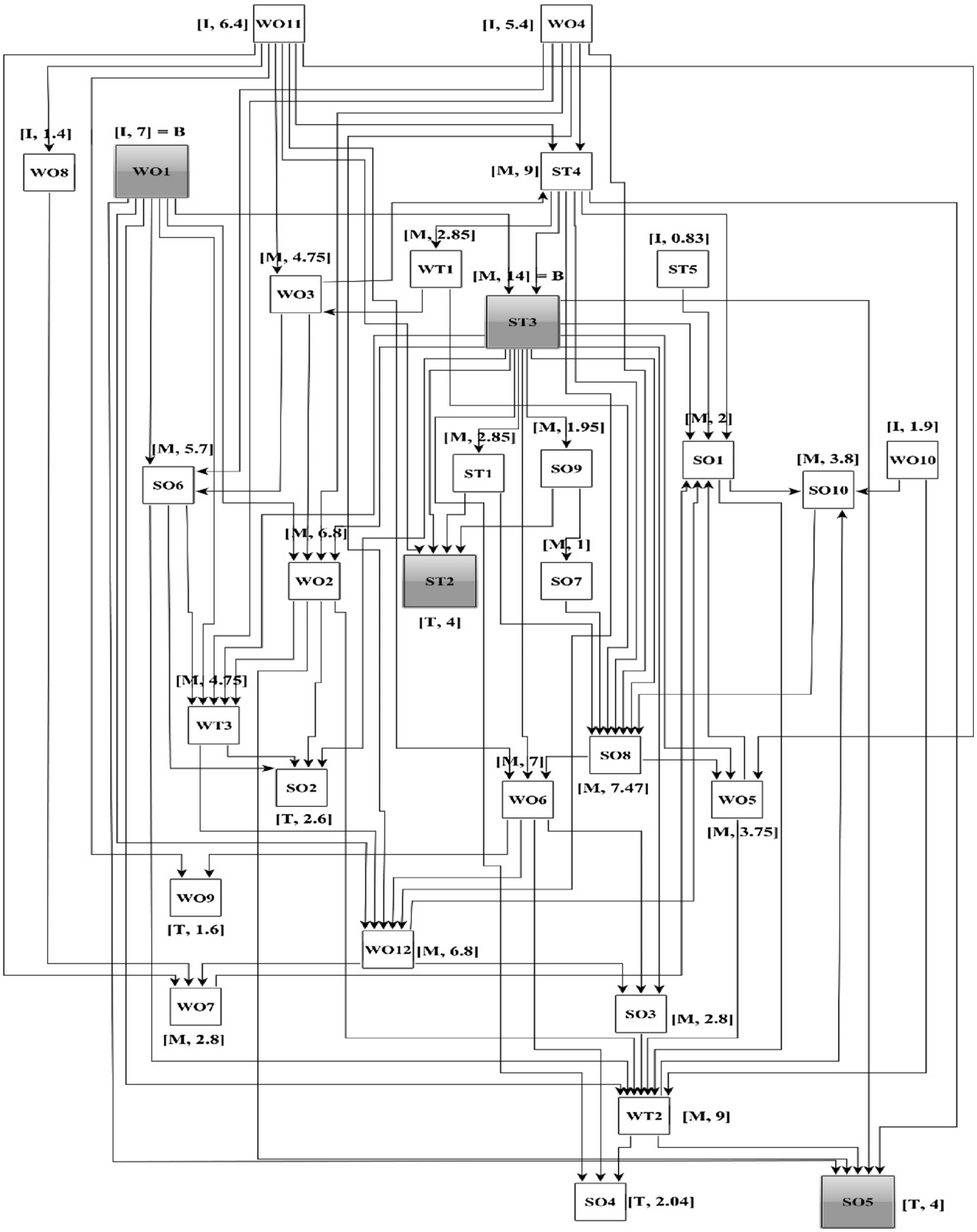


**Fig. 5.** Hierarchy of the policy strategies. 'I, 'M' and 'T' stand for 'initiation', 'mediation' and 'termination' strategies. The prominent strategies are highlighted as colored cells.

water resources (i.e. reclaimed water and desalinated brackish and seawater) can be considered in water scarce regions (Mousavi, 2005; Sheidaei et al., 2016). However, application of non-conventional water sources should be feasible from the financial, environmental, social and political points of view. Moreover, great public involvement and substantial changes in the current water management pathway are required. Irrigation water management should consider long-term management perspectives and integrated water management plans in order to reduce water crisis, in Iran. An integrated management should recognize multiple objectives of different stakeholders, interrelated dynamics of the agriculture sector with the other sectors and regional to global scales, variability of natural and social boundary conditions and benefits from various nonstructural and structural solutions. It is obvious that such an integrated management needs collaboration of

experts from many disciplines, development of new institutional arrangements between the public and private sectors, revision of the current water governance structure and consideration of new water resources (e.g. recycled and non-conventional water resources).

Also, a fundamental shift in water policy paradigm from command and control to market-driven policies is needed (Fig. 5; SO2). Water market is an essential instrument to reallocate water between competing users under water stress. The experts and policy makers believed that development of water right market and full-cost recovery pricing policy can encourage the farmers to increase the economic efficiency of water use and force those historical holders of water rights that are unable to make necessary adjustments to stop irrigation and transfer water to other users. The implementation of reliable water market calls for continuous regulation and monitoring of water use as well as the development of price-setting mechanisms to support water trades and ensure that this reallocation process takes places efficiently.

## 4. Conclusion

Efficiency of water use is very low in the agriculture sector of Iran and performance of many water management schemes is far from satisfactory. This study presented an approach to identify the numerous internal and external factors that affect planning, designing and implementing water management agendas and provide a set of strategies to solve the present problems of the irrigation water sector.

A combination of the SWOT and PESTLE analyses was used to describe the current status of irrigation water management in Iran. The SWOT analysis demonstrated 40 critical factors that reinforced or depreciated irrigation water management. An in-depth analysis of these factors suggested that irrigation water management should mainly concentrate on eliminating the major weaknesses, as well as mitigating the threats. In this respect, the decision makers should perform different activities to overcome the main weaknesses and threats identified by the analysis. Furthermore, to take into account all aspects of the inefficient use of irrigation water in Iran, the SWOT factors were grouped as the political, economic, social, technological, legal and environmental factors. Findings indicated that the problems that are faced in irrigation water management are complex and multi-faceted. Legal, social, technological and political challenges were identified as the key factors for failure of irrigation water management and it was found out that the government has achieved a limited success in preventing the serious irrigation water problems. It seems that the SWOT/PESTLE analysis is a very promising approach for managing water resources and provides a deeper and more precise understanding of the current realities of water management, compared with the standard SWOT.

According to the findings, the government should revisit its approach in order to solve the present problems of the water and agriculture sectors. In this respect, the most common challenge is making decision about which solution strategies should be considered for ensuring sustainable management of irrigation water in Iran. To make such important decision, the TOWS matrix was applied based on a combination of the external and internal factors that influence the planned actions within the irrigation water system. Also, bottleneck analysis was used to identify the prominent initiation, mediation and termination strategies that satisfy the principal criteria. ‘Rethinking the role of intensified agriculture in national development’, ‘raising the managers’ awareness and attitude toward the risk of water resource development plans’, ‘promotion of agro-based industries’ and ‘development of integrated plans to improve water efficiency’ were distinguished as the most important strategies for improving the irrigation water efficiency in Iran. This finding implies that the government should avoid populist and shortsighted actions and focus on fundamental solutions that have more noticeable impacts to manage irrigation water efficiently. Since Iran is water scarce country, these findings provide useful prospects for optimizing the use of limited water resources. Also, the hierarchy of strategies, which is determined in this research, can be applied as a road-map to enhance the resilience of irrigation water resources under the condition of water scarcity.

## Acknowledgments

This research was supported by the Ministry of Energy of Iran, deputy of Water Demand Management and Water Productivity Improvement. The authors gratefully acknowledge the contributions of Dr. Mojtaba Razavi Nabavi, Dr. Seyed Hamid Musavi, Mr. Mojtaba Akram, Dr. Amir Alambaigi, Dr. Teymour Sohrabi, and Dr. Mahdi Mohammadi Ghaleney in this work.

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